16 SEPTEMBER 1959

GAS IN INDUSTRY

Supplement to the "GAS JOURNAL"

Vol. 2 No. 16

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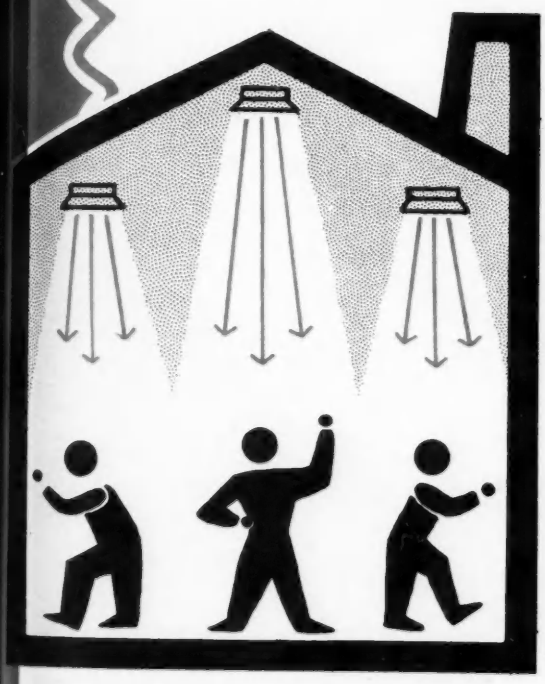

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GAS IN INDUSTRY

SEPTEMBER 1959
Vol. 2 No. 16

FEATURES

GAS IN A SMOKELESS ZONE. By J. R. Teale

NORTH THAMES SERVICE —INCINERATION, CLOTHES FINISHING, GLASSBLOWING.

RUNNING-IN FOUR-STROKE ENGINES WITH TOWN GAS.

TINNING OF COPPER WIRE.

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Editorial

Clearing the Air

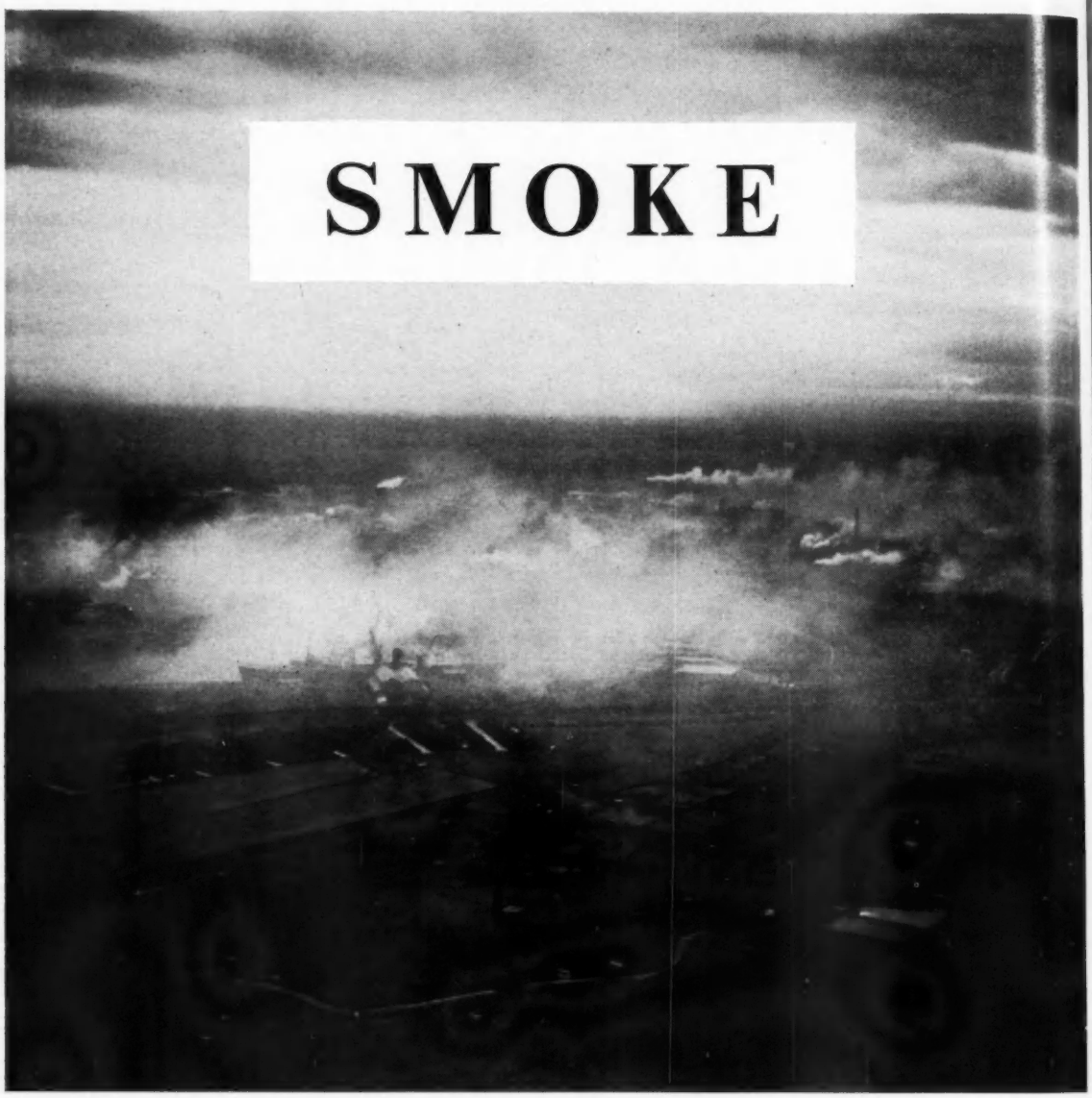
A SMOKELESS and unpolluted atmosphere has been a state of perfection for which a number of people have striven for something like a century. Even in the 1850's railway locomotives were by regulation compelled to restrict the volume of smoke issuing from their funnels while standing in stations. For a time this was taken sufficiently seriously for attempts to be made by the railways to burn coke in place of coal, but as the design of locomotive fireboxes improved, the volume of smoke emitted was reduced even when coal was in fact used.

Although many deplored the soot and smoke in our industrial cities, especially in the Midlands and the North, little was done about it. The damage done to historical buildings and the enormous cost incurred each year in fighting corrosion caused by sulphur dioxide did not make any real impression on public opinion. The insidious idea behind the North Country saying, 'Where there's muck, there's brass,' seemed to hold the population in thrall, and of course suited the more conservative manufacturer who was unwilling to spend money on the appropriate plant for reducing smoke emission.

It was the 'smog' and the 4,000 deaths it caused in London in 1952 which brought home the ill effects of a smoke polluted atmosphere to the man in the street. This, of course, was not quite true in the North West of England, for it was in Manchester that some of the earliest efforts were made to combat the smoke nuisance for which South Lancashire was almost celebrated.

In a paper on smoke abatement, by Mr. J. R. Teale, Senior Industrial Gas Engineer in the Stretford district of Manchester, which we are publishing this month, we read of the measures taken by the Manchester City Council to reduce the atmospheric pollution in the centre of the city as early as the late 1930's. With the outbreak of the war plans had to be shelved and directly afterwards the shortage of fuels made it difficult or impossible to regulate the fuels burnt in any specific premises. As the supply of fuel improved so steps could be taken, and a smoke control area was declared in the centre of Manchester in May, 1952. But this was the city's commercial centre containing shops, offices, social clubs, etc., all of which could be heated by central heating systems consuming smokeless fuel. But the area of the zone was being added to and appeared to be approaching the important Trafford Park area in neighbouring Stretford. Here in the industrial centre of Manchester would be the real test for the possibilities of an unpolluted atmosphere in a concentrated industrial area. The industrialists began to realise that something should be done before compulsion from the City Council was brought to bear.

The installation of fuel-saving equipment, by making better use of the fuel burnt, reduces smoke emission to a marked degree and is a big step forward, but the change from a crude smoke-producing fuel such as raw coal, or even a sulphur dioxide producing fuel, oil, to a refined fuel such as gas is the real solution, and Mr. Teale shows how it improves working conditions at the same time.



How gas beats a modern menace

SINCE 1945 three important reports have been submitted to Parliament dealing with the use of fuel in this country. Each report received a good deal of publicity by the radio and the national Press until, eventually, the public became acquainted with the phrase 'the national fuel economy.'

Another national problem, atmospheric pollution, was mentioned in each report but the public did not unduly concern itself with that problem until December, 1952, when 4,000 deaths in London were attributed to a fog which blanketed the city during that month. It was after that catastrophe that the general public became more conscious of 'smog' and its lethal implications.

When bituminous coal is completely burned the oxides of sulphur, which are contained in the products of combustion, are the most harmful because of their corrosive and toxic qualities. There is also the residue of ash some of which, if there is a strong flue draught, is carried, with the products of combustion, into the atmosphere. When coal is not completely burned, and this is generally the case, pitch, tar and soot are also produced.

All these products are the main cause of pollution of the air, and they all have a wasting or corrosive effect upon buildings, textiles, metals, paintwork, etc.

A consequence arising from the deterioration of buildings and textiles is the large sums of money required for maintenance and cleaning and it has been estimated that the masonry of the Town Hall in Manchester is ingrained with dirt to a depth of at least half-an-inch.

It has also been estimated that, in heavily polluted areas, the cost of laundry is 50% above that in non-polluted areas, an additional estimated

cost due to pollution of £25 mill. a year. A further consequence of air pollution is the loss of ultra violet and visible light. Arising from the loss of light are:

1. Because of the necessity of artificial illumination during the day-time, it is becoming quite frequent for conditions of lighting which are normally associated with night to occur during the day. There is, therefore, the additional cost for 'daylight' lighting, which, however, does not include the price of inconvenience to the population, since this figure cannot be assessed.

2. A loss in efficiency in our road and rail communications caused by bad visibility. Irritating delays are not the only consequence of bad visibility, but there is also the increase in accidents to all forms of transport.

3. An increase in rickets and respiratory diseases. Table 1 shows comparative death rates from bronchitis in England and Wales and the Scandinavian countries. The loss of ultra-violet and visible light gives rise to rickets and tuberculosis in children. The loss of light and the presence of tar and soot in suspension in the atmosphere give rise to many lung diseases and ailments, which make necessary extra medical and hospital services.

Recent estimate

Many attempts have been made, in this country, to assess the cost to the nation of pollution of the air, and the following is an extract from the Report by the Committee on Air Pollution, which gives the most recent estimate.

'. . . After examining all the evidence we have been able to obtain we feel justified in stating that air pollution is at present costing the nation about £25 mill. a year in terms only of losses that can be given a monetary value.

TABLE 1

Death rates from bronchitis per 100,000 of the population

Country	Year	Males	Females
Denmark ..	1951	2·2	1·9
Norway	1951	5·5	5·8
Sweden	1951	5·0	4·0
England and Wales	1951	107·9	62·7
	1952	83·8	42·0
	1953	91·9	47·6

This does not include the value of the fuel that is lost through incomplete combustion, one of the main causes of smoke. This probably amounts to between £25 mill. and £50 mill. a year, and represents a waste of coal—possibly as much as 10 mill. tons—which the nation cannot afford, and may be still less able to afford in the future. Nor as we have said do they include those costs that cannot be measured in terms of money, though they may be immense, for instance, the loss of happiness and health.

From whence, then, does this pollution emanate? It can be broadly classified under four headings:

1. Railway smoke.
2. Motor vehicle exhausts.
3. Industrial smoke.
4. Domestic smoke.

The first two categories do not come within the scope of this paper, but they can be briefly referred to.

It has been estimated that the source of one-seventh of all the smoke discharged into the atmosphere is the coal-fired railway engine. Most of this smoke is produced by stationary engines and at shunting yards. It has been suggested that coal-fired railway engines should not be allowed to enter terminal stations and that the carriages, etc., should be shunted into the stations by means of a diesel engine. British Railways, however, are now in process of electrifying the existing railway system, thus eliminating any inconvenience caused by the former proposal.

From a paper by

J. R. TEALE

Assoc.M.Inst.Gas E., A.Inst.F.

SENIOR INDUSTRIAL ENGINEER,

STRETFORD UNDERTAKING, MANCHESTER GROUP, N.W.G.B.

to the Manchester District Junior Association of Gas Engineers.

Motor vehicle exhausts as a source of atmospheric pollution are becoming increasingly important as revealed by the rising annual sales of motor vehicles and the ever increasing congestion on the roads. It is in the large towns and cities where there is the greatest air pollution, and inevitably, due to the commerce of these cities, there is a large amount of road traffic. The large amount of traffic and the inadequacy of the existing road system to cope with it, causes the traffic congestion and the fumes emitted from the exhausts at low level are responsible for further pollution to the atmosphere.

Approximately 40% of the smoke discharged to the atmosphere is caused by industrial smoke. Smoke abatement is synonymous with fuel economy, and it is a fact that, apart from some special processes, the emission of visible smoke from large industrial installations can be avoided.

It is essential that a boilerman or stoker is trained for his job, and greater instrumentation would assist him in his efforts to get the most possible out of his fuel. Another factor which is frequently overlooked, and which incidentally, a trained attendant would always ensure, is frequent cleaning and maintenance of the plant.

The special processes mentioned earlier include chemical works. It is the obligation of these industries to reduce and, if possible, eliminate their contribution towards the pollution of the air. Their efforts are frequently inspected by the Alkali Inspectors, who are empowered, if it is ever necessary, to take legal action to enforce the industries to meet their obligations. This, however, is very seldom necessary.

Mention has been made of the effects of smoke on living conditions; the products of combustion which are most harmful are the oxides of sulphur oxides. On combustion of a fuel which contains sulphur, the sulphur combines with the air for combustion and forms sulphur dioxide and sulphur trioxide.

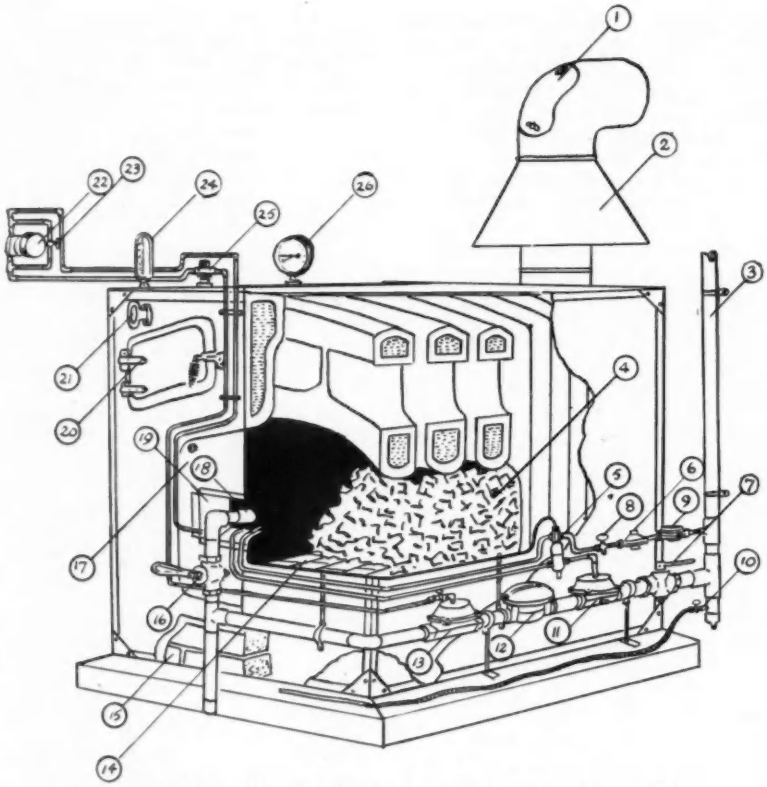
These oxides, in the presence of water, will form sulphurous and sulphuric acids. When the oxides are liberated into the atmosphere, they will form these acids during a wet day and consequently attack almost anything on which they fall.

Coal, coke, gas and fuel oil all contain sulphur and on combustion will produce oxides of sulphur. As far as the domestic coal fire is concerned, very little, if anything, can be done to reduce the emission of sulphur oxides into the air. The same applies for small scale oil installations.

Oxides discharged

With electricity it is claimed that no oxides of sulphur are emitted but quite a large quantity of the oxides are, in fact, discharged at the works. The average amount of SO_2 falling in London in 1952 was 35 tons per sq. mile per annum, whereas, the winter readings taken in the neighbourhood of Battersea, Fulham and Lots Road power stations, which in 1950 burned 29,000 tons of coal per day during the winter, was equivalent to 220 tons of SO_2 per sq. mile per annum.

The gasworks remove quite a high proportion of sulphur during the process of gas and coke production and



Conversion of a solid fuel fired central heating boiler to gas firing.

1. *Flue cleaning door.*
2. *Down draught diverter.*
3. *Gas supply.*
4. *Broken refractory.*
5. *Thermo-electric pilot device.*
6. *Pilot governor.*
7. *Main control cock.*
8. *Guarded head loose key cock.*
9. *Low pressure cut off valve.*
10. *Lighting torch.*
11. *Low pressure cut off valve.*
12. *Constant pressure governor.*
13. *Relay valve.*
14. *Refractory tiles.*
15. *Ashpit opening sealed with firebricks.*
16. *Burner control cock.*
17. *Sheet steel door.*
18. *Hypact burner.*
19. *Air intake slot.*
20. *Boiler flue door.*
21. *Flue damper control.*
22. *Clock controller.*
23. *Clock by-pass cock.*
24. *Thermometer.*
25. *Thermostat.*
26. *Altitude gauge.*

discharge a relatively small quantity of pollutant. Coke and coal contain a similar quantity of sulphur, between .5-2.5%, but the main advantage of coke as far as pollution is concerned is that, on combustion, it does not give off smoke, and it only produces a small quantity of grit and dust.

Fuel oil produces a large quantity of sulphur dioxide. It is possible to remove the sulphur from the oil, but the cost is too great for it to be considered a commercial proposition. Town gas has a relatively low sulphur content and, as far as smoke abatement is concerned, it is the ideal fuel.

Of all these fuels then, it appears that town gas is the only one which not only eliminates the production of smoke but it virtually eliminates the production of sulphur oxides. Unfortunately, this point has not been pressed home sufficiently. Some authorities think that if the production of smoke has been eliminated the atmosphere is not being polluted.

In Manchester it is proposed to erect an extension to a hospital and the Manchester Corporation have stated that, to comply with the Clean Air Act's requirements, they would like the extension to be heated by either electricity or gas. The Ministry of Health, however, wants oil to be the fuel used to heat the building.

The Ministry, quite rightly, states that the use of oil complies with the Clean Air Act; but the Manchester Corporation wants clean air, not just smoke-free air. From the facts and figures mentioned above the advocacy of H.M. Ministers for the use of fuel oil is difficult to understand. At one moment they introduce a Bill which endeavours to clear the air of pollution, the next moment they advocate the use of fuels which discharge one of the most deleterious products of combustion.

It was in the North, in Manchester, where the first practical step towards the elimination of 'aerial sewage' was made. The Public Health Department considered that all the past efforts towards the abatement of smoke pollution had been after the fact. It considered that it would be a more positive approach to prohibit the production of smoke.

In 1938, under the supervision of the Chief Sanitary Inspector, a survey was made of all the appliances used in a central zone of Manchester. Elimination of smoke from this zone would have very little effect upon the smoke problem, and even if all Manchester was smokeless, polluted air would be carried to the city from the surrounding towns.

Zones clear

It has been found, however, that when a fog has settled on the city, the smokeless zones are relatively clear, since one of the conditions required to create a fog is the absence of air movement. The smokeless zone is then undergoing a natural fog, whereas the surrounding districts are suffering from a man made smog. The only pollution in the smokeless zone, under these conditions, is that given off by road transport exhausts, and that diffusing into the zone from the surrounding districts; any air movement, however, blows pollution from polluted areas into the smokeless area.

The result of the survey showed that very little smoke was, in fact, being emitted from the zone under consideration; but it must be realised that the Public Health Department was dealing with something new and it could only guess what public reaction would be, and so it had to tread very warily. Further work on the proposed smokeless zone was postponed due to the outbreak of hostilities.

Fuel shortage

In 1946 powers were obtained by the Manchester Corporation to create a smokeless zone, but the acute fuel shortage at the time forced the Public Health Committee to postpone once more the creation of the smokeless zone until the necessary fuels would be more readily available. After a further survey in February, 1947, and after ensuring that there would be adequate supplies of smokeless fuels, it was decided that on May 1, 1952, 'the square mile' would become a smokeless zone.

The date was subsequently advertised in December, 1950, in order to give the occupiers, within the pro-

posed zone, sufficient time to meet the requirements of the Act.

When the success of the central zone was assured, the Medical Officer of Health, Dr. C. Metcalfe Brown, proposed an extension to the smokeless area of approximately 130 acres. A survey was made of the area, and conforming with Section 35 (4) (a) of the 1946 Act, a request was made to the Minister of Health to confirm the extension of the central area. The confirmation was duly received and it was decided that the emission of smoke would be prohibited in this 'marginal area' with effect from May 1, 1955.

After further surveys the Health Committee decided to add two more zones to the central area; one zone with an area of approximately 53 acres and the other approximately 125 acres, in both of which the prohibition of smoke production became effective on May 1, 1955. On that date, therefore, an area of some 308 acres was added to the existing central zone of 104 acres, making a total area of 412 acres. Four more extensions were made to the smokeless zone in 1955, adding a further 33 acres.

'Where there's muck there's brass' is a saying which is attributed to the industrial North; but now, in Manchester, men of foresight and vision are endeavouring to dispute that philosophy. The North, which was the home of the Industrial Revolution, has begun a revolution which will affect our way of life to such an extent that it might be classed as a turning point in the history of mankind.

Guaranteed supplies

Before the Public Health Committee decided upon the date upon which the smokeless zone would take effect, it approached the local gas and electricity undertakings to ascertain whether they could meet the potential loads, and the Manchester Gas Undertaking guaranteed the necessary coke and gas supplies. This made it possible to publish the date for commencement of the smokeless zone, May 1, 1952, in December, 1950.

The work carried out by the industrial section fell under five main headings:

1. The design and installation of non-standard ignition torches.
2. The conversion of existing solid fuel central heating and hot water boilers to gas firing.
3. The installation of gas fired central heating and hot water boilers.
4. The installation of gas fired overhead radiant panels.
5. Advice on the conversion of smoke producing industrial appliances to smokeless operation.

Many central heating and hot water boilers in the city are fired by either coke or other solid smokeless fuel. By implication, the 1946 Manchester Corporation Act forbade the use of wood and paper for ignition purposes, so a gas lighting torch becomes the only practicable method of ignition. The industrial section realised that there would be a demand for such a torch, and so decided to design one, bearing in mind that all gas fired appliances and equipment should include the following: (a) ease of operation, (b) safety in application, (c) low running cost, (d) low capital cost, (e) long life, (f) good aesthetic design.

Ignition methods

The domestic ignition poker was neither large enough nor robust enough to cope with lighting a central heating or hot water boiler. An appliance for igniting large quantities of coke was already on the market, but since it was used for lighting cupolas at iron foundries, it required high pressure air. Air under pressure was unlikely to be available, and an appliance to meet the general case was needed, so it was decided to consider two methods of ignition.

(i) A burner inserted in the solid fuel bed.

(ii) A burner fitted underneath the fire bars.

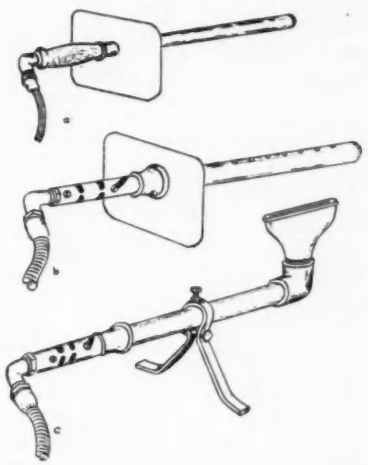
The simplest form of burner for insertion into the fuel bed would be a drilled mild steel tube, capped at one end and the other end connected to a flexible tube to the gas supply.

There are, however, several difficulties affecting the efficient operation of this method of ignition, the most important of which is that solid fuel offers a considerable resistance to the flow of air, so the gas would not be able to obtain sufficient air for complete combustion until it had left the fuel bed. If a pre-aerated burner is used, this objection is overcome, but for the same gas rate, a larger diameter of burner tube is needed, which

TABLE 2

Boiler putput B.t.u./hour	Diameter of mixing tube (in.)	Gas rate (cu. ft./hour)	Time required (Minutes)	Quantity of gas used to ignite coke (cu. ft.)	Cost of lighting up boiler (pence)
904,000	1½	144	20	48	4·85
718,000	1½	144	18*	43·2	4·37
313,000	1¼	100	20	33·3	3·38
141,000	1	72·2	20	24·0	2·44

* Using either coke or coalite.



Types of gas poker suitable for lighting up coke-fired central heating boilers to avoid the use of sticks and paper.

increases the weight of the burner and reduces its ease of operation.

Another objection is that a special steel door would have to be fitted every time the burner was used, to conserve the chimney or flue draught and to avoid retarding the 'spread' of the ignited coke. The burner might occasionally be left in the boiler, which would considerably reduce its life.

With the second type of burner the fire doors can remain shut, and so retain the chimney draught, which is able to draw the flames from the front over the unignited fuel and cause the necessary 'spread.'

By igniting the fuel at the front, only a short burner would be required, and, consequently, the burner would be easier to handle. Furthermore, if the burner was left in position in the ash pit, it would not affect the life of the burner.

Speedier results

The arrangements for lighting the boilers in the city vary considerably. Some firms ignite their boilers at the beginning of the heating season and do not allow them to go out except for insurance inspection or periodic cleaning; other firms allow the fire to die down at week-ends and re-light it on either Sunday evening or Monday morning. With the latter procedure, the coke should be ignited within 30 minutes. The under firing method of ignition gave the speedier results, so a burner was designed which would meet the necessary requirements.

The torch consists of a two stage injector, which ensures a high degree of primary aeration, and is connected to a heat-resisting nozzle by means of a mild steel mixing tube. This nozzle has a single slot for the burner port,

and it is inserted between the firebars. The whole burner, which is supported on a bipod, is placed below the firebars and the flame fires between them. Lighting instructions were issued to be placed in a prominent position near every lighting torch. Thirty-eight lighting torches of this design have been installed in the central smokeless zone by the Manchester Undertaking. Several private contractors have also used this design of burner. Table 2 gives typical results obtained with these lighting torches.

Conversion requests

Catering establishments, which possess ovens, grillers, etc., fired by solid fuel, applied for pokers with which they could ignite the fuel. In some cases, special gas lighting torches were designed for these appliances also.

Several requests were received to convert existing solid fuel central heating boilers to gas firing. In each of these cases the installation of a gas fired central heating boiler was recommended, because of its higher thermal efficiency. Where the consumer insisted upon a boiler being converted to gas firing, and the boiler was suitable for conversion, the industrial section carried out the necessary work. A typical layout of a gas conversion set for a solid fuel boiler is shown on p. 208.

The burner unit consists of a single Hypact burner firing on to broken refractory brick which is placed on tiles in the fire box. The fire doors are replaced by a sheet steel door and there is a carefully designed air intake slot in the sheet steel front through which the burner enters the fire box. The controls consist of a burner tap, a relay valve, a governor, a low pressure cut-off valve which operates in conjunction with a thermo-electric pilot device, a main control cock, a permanent pilot which is independently controlled by a guarded head loose key tap, a governor and a low pressure cut-off valve. A weep pipe is run from the relay valve to a thermostat which controls the temperature of the water leaving the boiler.

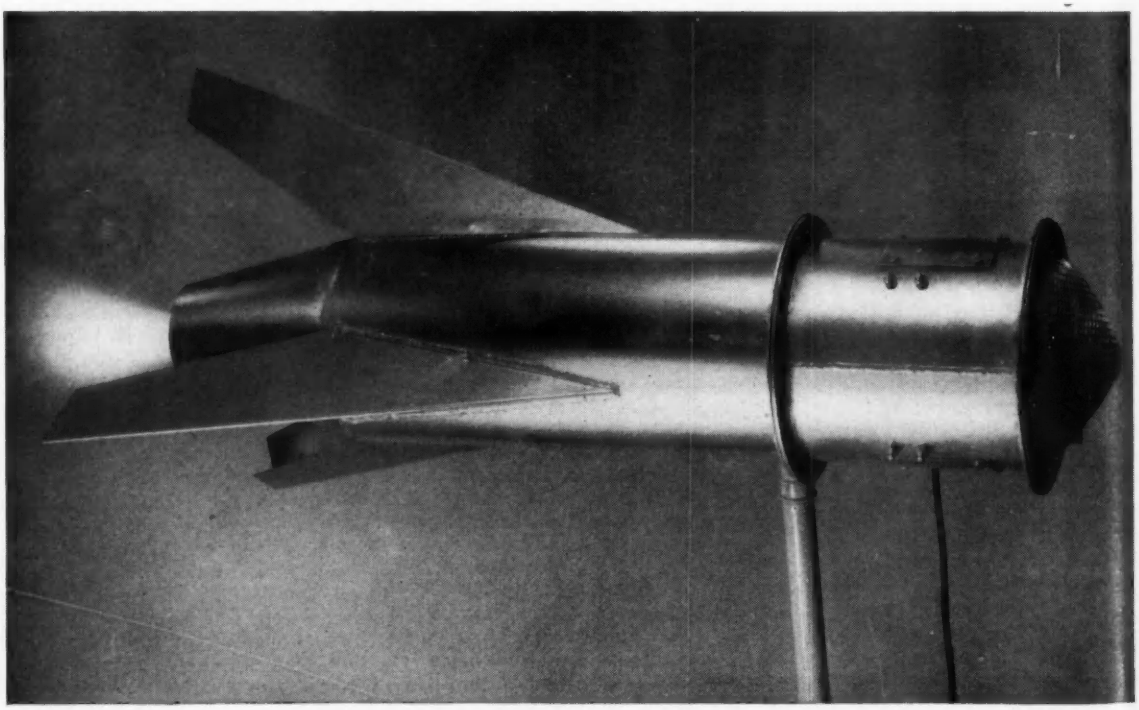
Clock controller

For reasons of fuel economy and convenience, a clock controller can be attached to the weep from the relay valve. The clock control causes the boiler to light up and shut down at pre-determined times. A room thermostat, which is placed in a pilot room, can also be attached to the weep. This controls the maximum temperature within the pilot room. A further refinement to the gas fired central heating system is an anticipatory control, known variously as Weatherstat, Variostat and Weather Pilot. This is attached to a sheltered part of the outside wall of the building. When the outside temperature rises, the control causes a reduction in the temperature of the flow water. A draught diverter is installed in the flue.

Since the announcement of the proposed smokeless zone in the centre of Manchester, 38 gas fired boilers and 11 conversion units have been installed within the city.

The performance figures of a typical conversion are as follows:—

Boiler ..	No. 7 F.N. Robin Hood sectional boiler.
Rated output ..	289,000 B.t.u. per hour.
Gas rate (uncorrected) ..	680 cu.ft. per hour.
Gas pressure (at burner) ..	15/10 in. w.g.
Flue gas analysis (dry).	
CO_2	9.2%.
O_2	5.8%.
CO	0.01%.
Flue gas temperature ..	572°F.
Overload test (with 20% volume overload in accordance with B.S.S. 717 (1950).	
Gas rate (uncorrected) ..	820 cu.ft. per hour.
Gas pressure (at burner) ..	22/10 in. w.g.
Flue gas analysis.	
CO_2	11%.
O_2	4.6%.
CO	0.01%
Flue gas temperature ..	590°F.



Gas-fired drier suitable for drying large foundry moulds in situ.

Under normal working conditions the calculated flue loss from the above figures is 23% and assuming a 5% loss from the boiler by radiation and convection the thermal efficiency of the boiler is 72%.

There were several cases of gas fired central heating boilers replacing existing solid fuel boilers, but, in the majority of these cases, these were installed by heating engineers. The industrial engineers were called to these installations to ensure that the gas supply was adequate. They also had to discuss running costs; and, in the majority of cases, adjust and test the controls on the boilers.

When the installation was complete, the consumer was always encouraged to have the boiler regularly cleaned and inspected.

Few panels

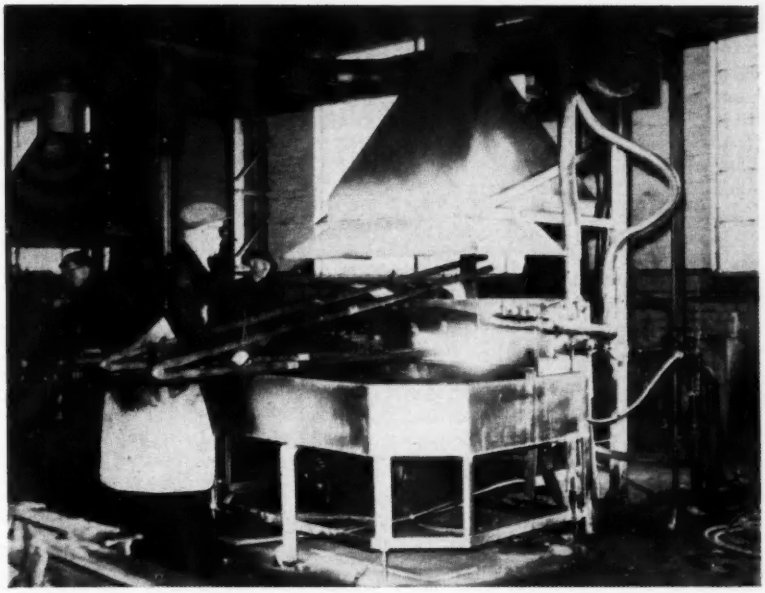
Not many overhead radiant panels were installed in this zone; because, as mentioned earlier, the zone comprised mainly offices and shops.

As the smokeless zone extended beyond the city there was a variation in the requirements. It was found that in some areas the preponderance of work was in the nature of modifying domestic space heating equipment, whereas, in other areas, the greater amount of work was devoted to applying smokeless fuels to manufacturing processes.

Some industrialists in surrounding districts are already modifying their equipment in anticipation of future extensions of smoke control areas. A case in point is the original method of firing a grease blending kettle. Coal was loaded on to the brazier, and, after ignition, the brazier containing the burning coal was placed underneath the vat. When the required temperature was attained the brazier was removed. The products of combustion filled the workroom when the brazier was removed. The Gas Board has recently modified the combustion chamber, and the appliance is now fired by gas, utilising a Hypact burner.

Less time

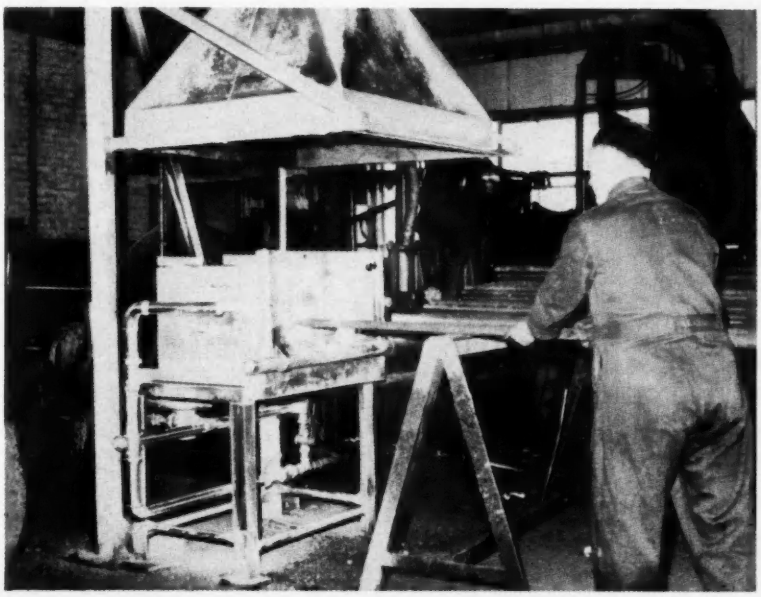
Originally a workman mixed the various oils, and he used to call to the fireman to tell him when to move the brazier so that the grease would not be overheated, or to insert the brazier when the contents were cooling. This procedure has now been eliminated. The operator can still control the temperature, however, but he now only has to operate a thumb tap which is fitted on the weep pipe which leads from a relay valve. Besides eliminating smoke the time required to heat the oil has been reduced. It now only takes two hours to heat a 13-cwt. kettle as opposed to the four hours required when using coal. Furthermore, the cost of heating the batch is now 17s.—compared to 25s. under the old conditions of heating.



Oil-fired forging furnace. Note operators are wearing goggles to avoid the glare of the oil furnaces.

A wire manufacturer in the Trafford Park area has several galvanising baths, one of which, until recently, was fired by coal. The coal-fired bath was extremely inefficient, in fact it could not be relied upon to attain melting temperature. A further worry of the manufacturer was a food warehouse erected adjacent to his premises, the eaves of the roof of which were very near the chimney stack serving the coal-fired bath. The smoke from the chimney sometimes entered the warehouse, with the inevitable complaints to the wire manufacturer, who in due course approached the Gas Board. A scheme was submitted whereby the bath could be converted to gas firing. It was accepted and duly carried out.

The required temperature of the zinc is now easily attained, and



The same forging furnace converted to gas firing. There is no longer any glare and the conditions of working are much improved.

furthermore controlled and recorded. Unfortunately, to date, a full load of wire has not been passed through the plant, and so no comparison can be made with solid fuel as far as performance is concerned; but, the elimination of smoke has been achieved.

In the same area there is a firm which, in the course of its process, has to burn large quantities of rubber. The resultant smoke and smell has caused many letters to be written to the press by people who reside in the neighbourhood. A gas-fired incinerator is now being erected. Gas burners are to be fitted in such a position that any smoke produced will be consumed in the flames. The installation has not yet been completed, but when it is, we anticipate that the industrialist, the local inhabitants and the Smoke Abatement Officer will breathe—clean air.

There is a firm in the Trafford Park area which manufactures superheaters. Until recently this firm used oil-fired forging furnaces. They approached the Gas Board and asked whether it would co-operate with them in solving three problems: (1) The furnaces caused a large amount of dirt, (2) the fumes given off were causing a nuisance, and (3) it was desirable that fuel and maintenance costs be reduced.

The industrial section co-operated with the manufacturer and produced a prototype furnace. After a few modifications the furnace was accepted and eventually installed. The luminosity of the flames in the oil furnaces made it necessary for the operators to wear smoked glasses, but there is very little glare from the gas furnaces, and the atmosphere within the works is now quite clear and the fumes have been eliminated.

Comparable costs

As far as running costs are concerned, they are comparable with the oil. The maintenance costs have been considerably reduced. When oil was used, the furnaces had to be reconstructed every two weeks, now under gas firing they only have to be rebricked every six weeks. This was a case of where an industrialist, who, by bettering the conditions of his employees, also made a contribution towards a reduction of atmospheric pollution. This also tends to substantiate the arguments concerning fuel oil. Under the Clean Air Act the manufacturer was entitled to use fuel oil but he complained of fumes.

In 1953 the Minister of Labour and National Service issued Regulations with regard to iron and steel foundries. Some of the Regulations dealt with the dust and fumes which are encountered in the foundries. Although the Regulations, which are part of the Factories Act, were primarily intended to give a standard of working conditions with regard to safety and health, they do also contribute towards the elimination of smoke.

There are many ways in which the gas industry can and does assist foundry managers to comply with the Regulations. It used to be the practice, when drying or preheating ladles, to light a wood, coke or coal fire within the ladle. In some factories, large exhaust fans had to be installed to remove the smoke from the foundry caused by these fires. This large air change meant the installation of large heating installations and a consequent increase in capital and running costs. The foundrymen, however, had the smoky atmosphere and the air another source of pollution.

Ladle drying

The trend today is to use gas for ladle drying and there are several types of burners which will accomplish the task. Most of the ladle drying burners are operated with high pressure air and low pressure gas. By working with this system, the products of combustion do not affect combustion of the gas as the degree of aeration is at least 100%. The products are also ejected at a high velocity which assists both the heat transfer and the products to heat all parts of the ladle.

Furthermore, there is no chance of the drying agent being extinguished as there is with solid fuel; once lit the gas burner remains so until the operator no longer requires it. The gas industry is also assisting the foundrymen in observing the Clean Air Act, at the same time increasing his productivity, by the gas firing of core and mould stoves. Their use has eliminated the previous practice of using solid fuel, and their even heating and reliability has also reduced the drying times and the number of rejects. Some moulds are so large that they have to be dried *in situ* and an early method of doing so was to suspend coke braziers over the mould.

The North Western Gas Board has developed two types of portable hot air forced circulation drying units for the purpose of drying large floor moulds. One type of unit is horizontally mounted, whereas the second type is vertically mounted. Gas-fired heaters are already on the market for drying floor moulds, but they are of heavy construction and, consequently, they are not as portable as would be desired.

A design which dispenses with all refractory brickwork follows gas turbine combustion chamber design and employs an air-cooled combustion chamber. An axial flow fan, rotating at 2,000 r.p.m., produces a high velocity air stream part of which is used for combustion of the gas. The remainder of the air cools the combustion chamber and mixes with the high temperature gases giving a resultant outlet temperature of 150-400° C. The rate of flow of hot air leaving the 12 in. diameter heater is approximately 30,000 cu.ft. per hour, with a gas rating up to 1,000 cu.ft. per hour.

This unit is designed for vertical fixing and is mounted on three legs, in the form of fins, which rest on the mould surface. A smaller version, which is for horizontal fitting, with a gas rating of 200 cu.ft. per hour, has been used for drying a machine bed, the dimensions of which were 5 ft. by 3 ft. by 3 ft. The sand thickness varied between 8 in. and 12 in., and the weight of sand, when wet, was 15 cwt. The mould was dried within 4½ hours, with a consumption of 1,000 cu.ft.

The foundry manager stated that this type of mould used to be dried in an oven fired by solid fuel, and the time required to dry it was 16 hours.

In all processes where heat is required in a foundry, gas firing can be used. In a growing number of foundries, in fact, gas is the only fuel used for firing the various appliances. It is now used for lighting cupolas, pre-heating air for cupolas, ladle, core, mould and sand drying; annealing, space heating, supplying hot water for ablutions, clothes drying and canteen facilities.

TESTING FLOORS IN AUSTRALIA, USING GAS

A fire-resistance furnace, burning 20,000 cu. ft. of gas per hour, has been designed and built by the Australian Gas Light Company for the Commonwealth Experimental Building Station at North Ryde.

The furnace was built to determine the fire-resisting qualities of floors to be installed in large buildings and plays an important part in enabling consulting engineers and architects to reconcile two main building points—safety and costs.

By the controlled use of gas it will be possible to watch and chart the effect of heat on a trial floor which will be placed on top of the furnace, the internal dimensions of which are 15 ft. long, 12 ft. wide and 6 ft. 6 in. high. It has air-cooled peepholes fitted with armour plate glass, through which observers can see and photograph what happens to the floor.

The furnace has been designed so that within five minutes it should reach a temperature of 1,000°F.

NORTH THAMES SERVICE

From time to time we devote space to the activities of the various Boards' industrial departments. In this issue we present short articles illustrating three facets of the work of North Thames Gas Board's industrial engineers.

Mullard House scheme

NORTH THAMES—1

THE post-war reconstruction programme in the County of London includes many tall office blocks, for example, Mullard House, and for these buildings the mechanical venting of gas-fired incinerators through a common flue is now an accepted practice. The design of these schemes has been carried out in recent years by the Headquarters Division of the North Thames Gas Board, whose services were called upon by the architects for Mullard House in the early planning stages.

The ladies and gentlemen's toilets are arranged one above the other on alternate floors of the 11-storey building. There are six lavatories in each toilet arranged in two rows of three, both rows backing on to a common service duct. An incinerator has been fitted in every lavatory of the ladies' toilets, making a total of 30 incinerators, six in each of the five ladies' toilets. Each incinerator has been modified by the makers to permit flush wall fixing above and partly behind each low level suite. A sheet metal frame finished in white enamel gives a neat and clean appearance to the installation.

The incinerators are served by three vertical asbestone flues housed in the service ducts, each flue venting two incinerators on each of the five floors. These three common flues rise to a roof top fan chamber where they are connected to three paddle-bladed fans each capable of handling 350 cu.ft. per minute against 5 in. w.g. This fan duty is on the high side by design, and provision has been made to adjust the pull on the flues by including a dampered tee branch at the fan inlet. Precautions have been taken against the transmission of fan noises by providing flexible fan connections of asbestos cloth and anti-vibratory fan mountings.

The fans are arranged to discharge vertically into an upper compartment ventilated on three sides, thereby permitting the prevailing wind to assist in dispersing the products of combustion by cross ventilation and minimising back pressure. Fan failure controls ensure that gas cannot pass to the main burners of the incinerators unless the fans are operating. Each incinerator is fitted with a bi-metal flame failure device and permanent pilot.

Left: *One of the incinerators modified by the makers to fit flush to the wall and installed above the cistern of a low level suite.*

Right: *View of a typical service duct between two rows of three lavatories showing the incinerator flues with cleaning covers on the bends.*

Fashions and gas

THE 'FINISHING TOUCH' APPLIANCES

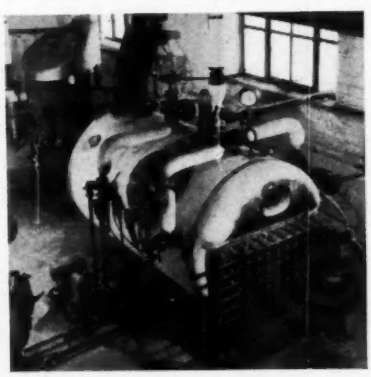
One floor of the factory with steam/electric hand irons and a Hoffman press clearly visible.

Over 1,000 other firms

WITH the Sack look, Empire line, Princess line and the host of other styles for women which have been introduced in the last few years, only a prophet would dare to forecast what the fashion will be more than a few months hence. No manufacturer can afford to hold large stocks of garments without a guaranteed market and must, therefore, be prepared to produce almost at a moments notice, considerable quantities of the particular style in vogue at the time. This means that the production equipment must be capable of being put to full use at very short notice if full advantage is to be taken of the prevailing market conditions during the seasonal boom periods.

London, as the centre of the fashion industry in England, contains a great many firms engaged in the manufacture of ladies' clothing. In the North Thames Gas Board's area of supply alone, there are well over 1,000 such firms with the numbers of employees varying from half a dozen or less to many hundreds.

NORTH THAMES—2



A view of the boiler room at Hebe Sports Ltd., showing the new fully automatic horizontal boiler. The vertical boiler retained for standby purposes is in the background.

Gas is almost universally chosen as the fuel to supply the steam necessary for the Hoffman presses, hand irons and pleating boxes which give the finishing touches to the thousands of garments produced daily.

Minimum of attention

Typical of the firms engaged in this class of work is Hebe Sports Ltd., whose factory is just beyond the City boundaries. Recently the steam demand for the 12 Hoffman presses and some 60 steam/electric irons exceeded that available from the two vertical boilers and it was decided to replace one of these by a single horizontal tube firing boiler capable of meeting all demands made upon it. This boiler, fitted by Isaac Braithwaite & Son (Engineers) Ltd., has combustion safeguard equipment and, being fully automatic in operation, requires the minimum of attention. The remaining vertical boiler has been retained for standby purposes and to meet possible future expansion.

Many of the 550 or so employees have their midday meals on the premises, with the food being prepared on a variety of gas appliances in the well-equipped kitchen.

HEATERS BEING DEVELOPED FOR CROP DRYING AND PREMISES

GAS-FIRED 'TeleHeaters'—being developed for heating homes, offices or workshops with clean heated air—can also be applied to crop drying. TeleHeaters will range in sizes from 60,000 B.t.u. to 1.5 mill. B.t.u. per hour.

The TeleHeater works on the counter-flow principle and the heated gases are taken through a bank of tubes, each tube having a loose chain form fitment to increase turbulence and raise the efficiency of heat transfer through the walls of the tubes to the fresh air being drawn around the outside.

The tentative figures for space heating for the nine models range from buildings with a floor area from 1,000 sq. ft. to 25,000 sq. ft. The units can be banked up for larger installations.

The manufacturers — ScotMec Works, Ayr, Scotland—will prepare layout and recommend ducting and grille systems, and will quote for a complete TeleHeater installation.

NORTH THAMES—3

The art of the glassblower

Top: *A glass door handle nearing completion. The glass is allowed to flow to the required shape under the watchful eyes of the glassblower.* **Right:** *A wine glass being reheated before further working, the blowpipe being constantly rotated to maintain the circular shape.*

ALTHOUGH automatic machinery has taken over many of the processes previously carried out by hand, there are still numerous operations where the skill of the individual is paramount. There are few trades in which the art of the craftsman is better seen than in the hand working of glass and many years of practice are necessary to acquire the skill to reproduce a dozen or more delicately shaped wine glasses identical in size and weight. The entire cycle of operations, from the molten mass of glass to the final shape, depends upon the glassblower, and it is on his experience and his skill with the blowpipe that the quality and finish of the article depends.

To maintain the plasticity of the glass during the forming operation, it is necessary to reheat it at frequent intervals. This is done using a 'glory hole' furnace—the most important piece of equipment used by the glassblower, next to his blowpipe. The partly-formed article is held on the end of the blowpipe, and heated mainly by radiation from the walls of the furnace, which are at a temperature of about 1,200°C. Our photographs show one of these gas-fired furnaces in use at the works of James Powell & Sons (Whitefriars) Ltd., in the North Thames Gas Board's area of supply.

When the craftsman is satisfied with the result of his efforts the surplus glass is removed before the article is passed through an annealing lehr to relieve stresses in the glass which, if not removed, may cause it to fracture in use.

FURNACE ORDERS WORTH £75,000 TO BIRLEC LTD.

THE Ford Motor Co., Ltd., has placed with Birlec Ltd. orders totalling £75,000 for three gas carburising furnaces. The largest is a continuous furnace, to be heated by gas-fired radiant tubes, for carburising transmission gears. It is the third such furnace commissioned from Birlec Ltd., and in common with the two already installed, will be of the pusher type, with twin tracks along which the work progresses on heat-resistant trays. With a carburising cycle of about 9½ hours, the furnace is designed to give a new output of some 800 lb. per hour.

Orders for two special Birlec sealed quench furnaces for clean hardening, carburising, and carbo-nitriding, have also been placed by the Ford Motor Co. Ltd. These gas-fired units will differ substantially in design from the 14 Birlec sealed quench furnaces already installed at Fords, of which eight are at the Basildon works and six at Dagenham.

A special feature of the new furnaces is that easily removable U-shaped radiant tubes are mounted horizontally in the heating chamber. Rated at 1,200 cu.ft. per hour, the furnaces will operate at a temperature of 950°C. Each furnace will have a work capacity of 9 cu.ft., enabling loads of 850 lb. to be handled.

BAKERS TO SEE GAS SERVICES

THE service which gas gives to all bakers but particularly to the 'small' man will be graphically shown at the Gas Council's stand at the International Baker's and Confectioners' Exhibition at Olympia, October 3 to 8.

The stand will include an animated sectional transparency of a new type of Reel gas-fired oven which is being developed by the Artofex Engineering Company in conjunction with the Eastern Gas Board. Features of this oven are forced re-circulation of hot air inside the baking chamber and indirect heating by a heat exchanger.

A 'live' gas-fired hot-plate on which a demonstrator will make and bake scones will also be included on the stand. Other catering equipment to be shown includes a fondant heater and a doughnut frier. A boiler for steam-raising will also be on display. Slogans and pictures illustrating the advantages of gas will also be of interest to bakers.

RUNNING-IN FOUR-STROKE ENGINES WITH TOWN GAS

TOWN gas is being used in the Worcestershire and Herefordshire Division of the West Midlands Gas Board by a nationally known company for running-in four-stroke air cooled engines. These engines are manufactured and exported to various parts of the world for driving pumps, generators and other ancillary equipment. They are made in five sizes, 98 c.c., 120 c.c., 220 c.c., 320 c.c., and 420 c.c. When the Divisional Industrial Department received the enquiry from the company it was ascertained that the gas would be used to feed the engines during a three hour running-in period. Petrol would be used as fuel during the brake horse power and speed tests which are carried out after the running-in.

Stipulations

The firm made a number of stipulations which had to be considered by the Industrial Department. These were:—

1. To avoid production problems the petrol carburettor would have to remain in position without alteration to the adjustment or controls.
2. Any attachment made to the engine should permit the petrol carburettor to be used without interference.
3. Any attachment to the petrol carburettor should not be excessive in size or weight.
4. As it was intended to carry out the running-in of 24 engines simultaneously in the same workshop, it was possible that an engine stopping for any reason might escape the immediate attention of the attendant. It was, therefore, essential that any gas leakage from the fuel intake of the stopped engine should be kept to an absolute minimum.
5. It would be preferable for the engine to start up on town gas.

Conditions 1 and 3 precluded the possibility of using a town gas carburettor which has been successfully used in another Division of the Board for running-in car engines, and condition 4 indicated that the gas supply to the engine would have to be as near as possible at atmospheric pressure. This also eliminated the use of an ordinary low pressure atmospheric injector which in this area has been employed in the past for running-in motorcycle engines.

Following discussions on the subject, it was decided to fabricate the air/gas mixer shown in Fig. 1 and fit this to the air inlet of the petrol carburettor. The diameter of the air/gas mixer venturi throat was made to 1.2 of the diameter of the venturi in the petrol carburettor. Along the back of the test bench to every four engines, a manifold gas pipe system, fitted to the outlet of a Keith Blackman type 3 zero governor, was installed, with an appropriate off-take cock adjacent to each engine. Half-inch rubber hose connected this off-take cock with the gas carburettor on each engine. This arrangement is shown in Fig. 2.

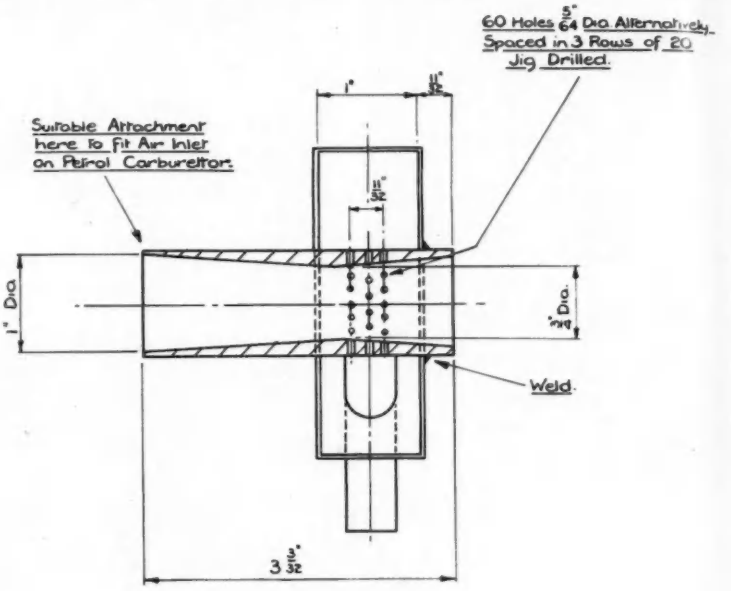

60 Holes 5/64" Dia Alternately Spaced in 3 Rows of 20 Jig Drilled.
Suitable Attachment here to fit Air Inlet on Petrol Carburettor.
1" Dia.
Weld.
3 3/32"

Fig. 1.

Satisfactory

When tests were carried out on a 420-c.c. engine, the arrangement proved completely satisfactory. In actual practice, the gas supply pressure to the carburettor was found to be in the order of $\frac{1}{10}$ in. w.g. and it was considered that the firm's fourth condition had been adhered to.

The installation has now been working for well over 12 months. It is interesting to note that following a detailed examination by the firm of the first engine to be run-in on gas, the firm considered it to be equally as satisfactory as an engine run-in on petrol, and, further, it was thought that it would be possible to reduce the running-in time of engines. This was probably due to the engine running at a higher temperature on town gas, for in the case of gas fuel there is no latent heat of evaporation present, as with petrol, and there is, therefore, a tendency for the mean temperature of the flame to be rather higher than that of a petrol/air mixture.

On the basis of one gallon of petrol being equivalent to 311 cu.ft. of town gas with a calorific value of 450 B.t.u. per cu.ft., it was assessed that the following gas consumptions apply for the different sizes of engine:—98 c.c., 19.5 cu.ft. per hour; 120 c.c., 39.0 cu.ft. per hour; 220 c.c., 48.0 cu.ft. per hour; 320 c.c., 78.0 cu.ft. per hour; 420 c.c., 90.0 cu.ft. per hour.

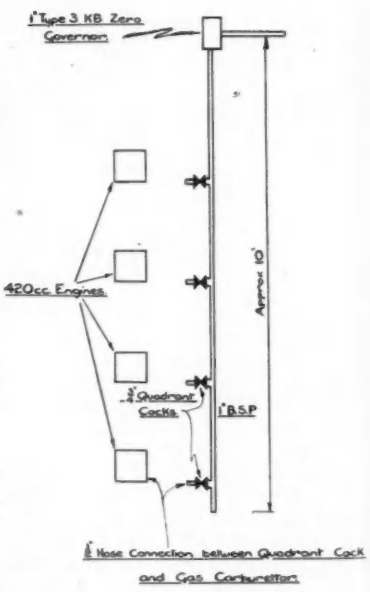

1" Type 3 KB Zero Governor
420cc Engines
Approx 10'
3/4" Quadrant Cocks
1" B.S.P
3/4" Hose Connection between Quadrant Cock and Gas Carburettor

Fig. 2.

INDUSTRIAL BUFFET

A compromise, says 'GAStronome'

WHEN the commercial caterer is faced with falling custom, he has several remedies. Among them is the ever-popular one of displaying food in the full view of the customer and leaving him to choose from that display. The factory or office caterer does well to follow the lead of his commercial colleagues, who after all, must surely know, as their living depends upon it.

What then are the alternatives available to the industrial restaurant facing a fall-off in every day patronage of the workers. Snack bars are a possible alternative, but lack the 'body' essential to provide the 1,000 calories meal required. The compromise between the full cafeteria service and the snack bar is the buffet. The buffet as the caterer knows it is the displaying of a variety of foods, in 'made up' form, easily served and so attractive to the customer that he feels that he is getting some of all he sees. That is the success of the buffet service. When one goes into a delicatessen shop to purchase a jar of pickles, one sees all the mouth-watering foods and one nearly always buys something else.

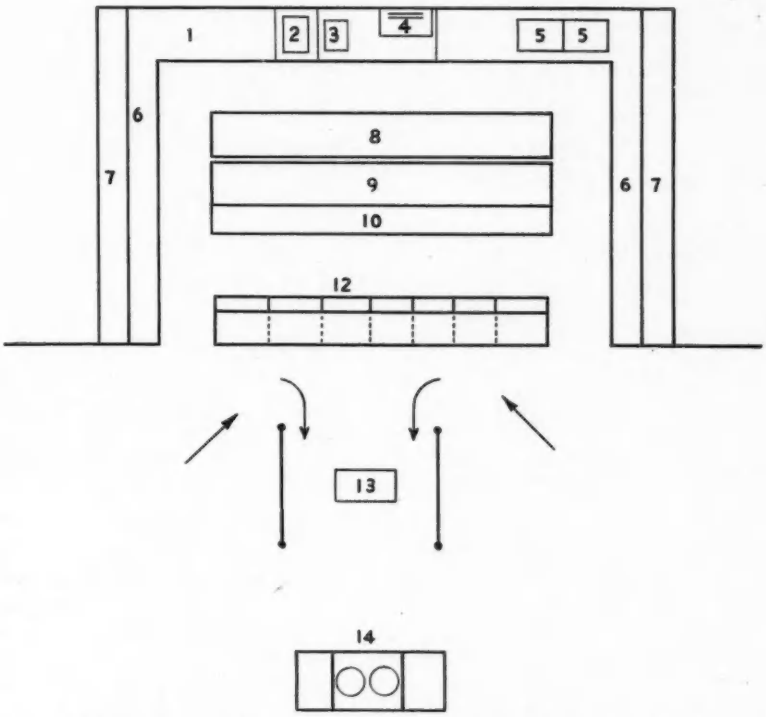
Advantages

What are the advantages to the industrial caterer? In addition to retaining or regaining the customer, it allows a full menu to be arranged, it attracts more revenue, at the same time providing certain foods at subsidised prices. It requires only a small area for kitchen preparation—indeed, it is possible to do away with the kitchen altogether by purchasing most foods ready cooked or prepared, the preparation and cooking being carried out in the buffet itself.

The kitchen staff problem that so many industrial caterers have to face is minimised, because the employment of part-time counter hands is possible, the number of cooks employed being at the ratio of, say, one per 50 customers.

Such a buffet service needs to be so planned and designed that food service is rapid and at the same time the display of food seen, therefore counter space must be on the generous side so that the counter servers are allocated ample space in which to work.

There are two alternative basic designs, both with merit enough to recommend their acceptance. One is to display the main food on a staging behind the counter, the other is to have the display on glass-covered shelving above the counter.



A typical layout of a buffet, suitable for serving up to 200 persons in an hour. Such an installation could be run by a staff of four.

1. *Preparation bench.*
2. *Deep fat fryer.*
3. *Griddle plate.*
4. *Grilling section.*
5. *General sinks.*
6. *Preparation with shelves under.*
7. *Storage cupboards over.*
8. *Preparation and resting bench.*
9. *Display shelf at 4 ft. 6 in.*
10. *Display.*
11. *Glass covered display.*
12. *Hotclosets and bains marie in sections.*
13. *Cash.*
14. *Self service of tea and coffee.*

Good to look at

Such foods that have to be cooked are done at the rear of the service and because it is desirable to continue the cooking throughout the meal period, the equipment and layout should be pleasing to look at, as it will be on view.

The equipment required for an all-the-year-round buffet service may include: *Deep fat fryers*—to cook straw chipped potatoes, meat and fish croquettes, hamburgers, Scotch eggs and the like. *Dry fry griddle plates*—to cook sausages, hamburgers, and to accommodate during service those foods that need to be kept hot. *Grill and salamanders*—for cooking sausages, ham and bacon cuts and such prepared foods that need intense heat to brown them and finish the appearance.

Hot cupboards and bains marie.—The problem of keeping food hot and ready for serving is met by using special hot cupboards. They will normally be installed at a raised level to ease the work of service and in the larger buffet installations may have doors fitted at the rear and front to speed up the replenishment of food and plates. The bain marie equipment will be used to accommodate such cooked foods as soups, hot sauces, garnishes to the main foods and similar supporting items.

Cold food trend

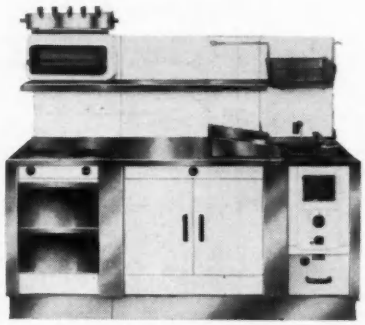
From the survey of the equipment required it will be thought that the amount of hot food is small. That is so, and reflects the trend towards cold cooked foods, particularly with the sweet course. Hot food throughout the complete courses is not essential to sound nutrition.

As an indication of the items of food that could be staged daily for a staff of 200, the following menu is given:

Cream Soup—Consommé
Sliced Beef—Ham—Veal Galantine
Savoury Vol-au-Vent — Sausage Rolls
Ham and Egg Pie
Grilled Sausages--Fried Hamburgers
Straw Chipped Potatoes—Potato Salad
Sliced Tomato—Russian Salad
Baked Beans—Pickles—Spaghetti
Lemon Meringue Pie—Fruit Jellies
Tea—Coffee—Fruit Drinks
Rolls—Butter.

The variations that can be made to the menu to give day-to-day appeal are numerous.

From the indicated menu, cooking with gas equipment is required for the soup and consommé, the sausages and hamburgers, straw chipped potatoes and food warming of some of the savoury vol-a-vent and sausage rolls,



The back counter unit, made by R. & A. Main Ltd.

the baked beans and the spaghetti. All other items are served cold, the incidence of cold and hot service of some of the foods depending upon local preference and the season of the year.

Beverage service.

The beverage service is best sited away from the main buffet as this slows down the speed at which the main food is served.

The equipment required will obviously need to be capable of making tea and coffee in bulk, and to keep such drinks at serving temperature without deterioration for at least one hour.

It is suggested that a boiler with a rated output of eight pints per minute of water at 212°F., together with glass-lined storage urns of four gal. each per 100 beverages served, be installed. The service of fruit drinks and estimated number required will reduce the bulk requirement of tea and coffee. The important thing is to keep adequate bulk available to meet any particular daily preference.

TINNING OF COPPER WIRE

THIS report records tests carried out on a gas-fired tinning bath at the Lydbrook Cable works of Siemens, Edison & Swan Ltd., Lydbrook, Gloucestershire.

A cast iron bath is used for the continuous tinning of copper wire and was originally heated by electricity. It was later converted to gas firing, due to high maintenance costs. The conversion was designed by the Area Industrial Department, South Western Gas Board, and the work carried out by the Maintenance Section of the company.

The bath is 35 in. long, 18 in. wide and 5 in. deep and has a capacity of 5¼ cwt. of tin. It is housed in a 3-in. firebrick lined steel casting, supported by an angle iron frame.

The burner system consists of two bar burners, each carrying 22 Bray jets No. 478, size ½. Air for combustion is admitted to the burners through two openings of 20-in. by 3-in. below the burners. The products of combustion are discharged through two slots 5-in. by ½-in. located at each end of the setting under the flange of the pot.

Automatic temperature control is provided by a Coley Model G temperature controller, calibrated 0—700°F. and working in conjunction with a ¾ in. Perl relay gas valve. This equipment is set to control the temperature at 520°F.

Copper wire is fed from coils into an acid or flux bath containing a 10% solution of hydrochloric acid, where it is cleaned electrolytically, the current being varied according to the size of wire being tinned. The currents used during the tests were as follows:—0.072-in. wire—30 amperes at 10 volts per strand of wire. 0.064-in. wire—26 amperes at 10 volts per strand of wire.

The wire is drawn through the molten tin, being guided by a series of small pulley wheels, thence passing through asbestos wool to remove excess tin, and finally through water cooled tubes before being recoiled on spools or bobbins.

From the above results it is apparent that the speed of the wire during tinning should be kept under supervision. It is felt that the recommendations made by the Area Industrial Department to use insulation brick in place of firebrick would have led to lower gas consumption and casing temperature.

Reproduced from Report No. 675/58 of the Industrial Gas Development Committee of the Gas Council (information supplied by the South Western Gas Board).

	Test I	Test II
Diameter of wire	0.072 in.	0.064 in.
Speed of wire specified	125 ft./min.	145 ft./min.
Speed of wire (actual)	134 ft./min.	129 ft./min.
Weight of copper wire tinned	280 lb.	350 lb.
Weight of wire/1,000 yd.	47.1 lb.	37.2 lb.
Length of wire tinned	5,900 yd. (approx.)	9,400 yd. (approx.)
Weight of tin used	5.9 oz.	9.4 oz.
Gas used	97 cu.ft.	136 cu.ft.
Calorific value	470 B.t.u./cu.ft.	470 B.t.u./cu.ft.
Heat used	45,590 B.t.u.	63,920 B.t.u.
Duration of test	44 min.	73 min.
Average CO_2 (full gas)	10.7%	10.9%
Average CO_2 (by-pass gas)	2.4%	2.4%
Average temperature of tin	521°F.	520°F.
Atmospheric temperature	69°F.	73°F.
Gas consumption per 1,000 lb. of wire	346.4 cu.ft. (1.63 therms)	388.6 cu.ft. (1.82 therms)
Gas consumption per 1,000 yd. of wire	16.44 cu.ft. (0.077 therms)	14.47 cu.ft. (0.068 therms)